KOKAI PATENT APPLICATION NO. HEI 1-273664

PRODUCTION OF A FIBER-REINFORCED METAL COMPONENT

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PRODUCTION OF A FIBER-REINFORCED METAL COMPONENT

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[*There are no amendments to this patent.*]

Specification

1. Title of the invention

Production of a fiber reinforced metal component

2. Claim of the invention

(1) A method of producing a fiber-reinforced metal component in which a preform is preheated and set in a die, then pressure molding is carried out, which method of producing a fiber-reinforced metal component is characterized by the fact that the aforementioned preform has a structure where a short fiber layer is arranged around a porous core material and placement of the aforementioned preform in the die is achieved by means of the porous core material of the aforementioned preform.

3. Detailed description of the invention

[Field of industrial application]

The present invention pertains to a method of producing a fiber-reinforced metal component.

[Prior art]

A method of producing a fiber-reinforced metal component in which a preform is formed sequentially with a first and second fiber layer on the surface of a cylindrical, air-permeable mold made of a material such as metal or resin mesh and placed inside a die and formed into a composite is known and is disclosed in Japanese Kokai [Unexamined] Patent Application No. Sho 61-87835 [1986].

In the above-mentioned manufacturing method, the melt is pressurized and permeates the fiber layer at the time of composite formation, and in this case, the melt and the individual fibers in the fiber layer come in contact and heat is robbed from the melt and solidification of the melt occurs before adequate permeation of the melt into the preform can be achieved. Therefore, a method in which a pre-heat treatment is applied to the preform before placing it in the die so that heat is not robbed from the melt by the preform can be used and is described in Japanese Kokoku [Examined] Patent Application No. Sho 62-38412 [1987].

[Problems to be solved by the invention]

However, in the case of the above-mentioned method, when the preform is mounted in the die, the aforementioned preform comes in direct contact with the die; thus, heat is robbed from the preform by the die and retention of heat in the aforementioned preform is not possible. Thus, solidification of the melt occurs before adequate permeation into the preform can occur as

in the above-mentioned method, and formation of an adequate composite cannot be achieved, in some cases.

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Furthermore, in general, a preform is used for local areas of the product and the preform is a small and thin material; thus, in many cases, the rigidity is relatively low. Thus, cracking is likely to occur in the preform due to the pressure of the melt inside the composite die and firm retention of the preform is not possible, and the preform is likely to shift from the mounting position.

The present invention is based on the above background and the purpose of the present invention is to prevent the die from robbing heat from the preform and to prevent formation of cracks in the preform, and furthermore, to securely retain the preform in the position where it is mounted inside the die.

[Means to solve the problem and effect]

In order to achieve the above-mentioned purpose, the present invention is a method of producing a fiber-reinforced metal component characterized by the fact that the aforementioned preform has a structure where a short fiber layer is arranged around a porous core material and the aforementioned preform is positioned in the die by means of the porous core material of the aforementioned preform so that a fiber-reinforced metal component can be produced in which pre-heating of the preform is done and it is positioned in the die, then pressure molding is carried out.

When the above-mentioned structure is used, the preform comes in contact with the die via a thermally insulating porous core material, and robbing of heat from the preform by the die can be prevented as much as possible.

Furthermore, the preform is reinforced with a porous core material and the rigidity of the aforementioned preform can be increased, and formation of cracks by the melt pressure can be effectively prevented.

Furthermore, the preform is positioned in die via the porous core material that serves as a reinforcement material, the preform can be retained in the die, and retention of the preform in the proper position in die can be securely achieved.

In addition, the preform is supported by the die, and area of the porous core material comes in direct contact with the melt and the melt can fill the porous core material as well, and formation of a composite with good integrity can be achieved.

[Application Examples]

In the following, the present invention is explained in specific terms with an application example using a mold for the apex seal groove reinforcement of the rotor in rotary engine as an example.

i) First, molding of preform 1 is performed.

As shown in Fig. 1 and Fig. 2, preform 1 has a structure in which a cylindrical short fiber layer 3 is arranged around bar-shaped porous core material 2, and the two ends 2a of the porous core material 2 extend beyond the end faces 3a of the short fiber layer.

In the present application example, a porous Ni material with a porosity of approximately 90% is used as the porous core material, and the aforementioned porous Ni material has thermal insulation properties.

In the present application example, alumina short fibers (95 $Al_2O_3 \cdot 5SiO_2$, density of 0.495 g/cm^3) are used for the short fiber layer, and the porosity of short fiber layer 3 is approximately 85%.

As shown in Fig. 3, the molding of the above-mentioned preform 1 is done by arranging porous core material 2 inside fiber forming mold 4 so as to form a circular space 5 around the aforementioned porous core material 2, the preform is then set inside short fiber solution 7 inside solution tank 6 and a vacuum is applied to interior of mold 4 via porous core material 2 under the above-mentioned conditions. In this manner, a molding having the shape shown in Fig. 1 and Fig. 2 can be produced. In this case, alumina short fibers, colloidal silica, cationated starch, anti-coagulant, latex type organic binder, inorganic binder, etc. are included in the above-mentioned short fiber solution. Subsequently, the above-mentioned mold is retained at a temperature of 600°C for 1 to 2 hours and removal of the organic binder is carried out; then, it is retained in a non-oxidizing atmosphere (or a reducing atmosphere) at a temperature of 1000°C for 1 to 3 hours, and baking of the colloidal silica (SiO_2) is achieved and mutual bonding of the short fibers is achieved.

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In this manner, formation of the aforementioned preform is completed.

ii) Subsequently, pre-heating of preform 1 is done.

Pre-heating of the preform is done under normal conditions, and in the present invention,

pre-heating of the preform is done at a temperature in the range of 300°C to 400°C.

In this case, heat loss of the melt does not occur at the time of permeation into the short fiber layer during the course of the pressure molding described below.

iii) Subsequently, preform 1 is positioned inside die 8.

In the present application example, the preform is used for reinforcement of the apex seal groove of the rotor in rotary engine; thus, as shown in Fig. 4, the preform is firmly supported by die 8 at both ends of porous core material 2 at the periphery of cavity 9 of die 8. In this case, 10 is the core in Fig. 4.

In this case, short fiber layer 3 of preform 1 does not come in contact with die 8, and only the thermal insulation porous core material comes in contact with die 8, and heat resulting from the aforementioned pre-heating of the preform is not robbed by die 8.

iv) Then, pressure molding is done.

As shown in Fig. 4, hot-melt molding method is used in the present application example as shown in Fig. 4. In other words, in the above-mentioned method, Al alloy melt 11 is forced into cavity 9 by plunger 12, Al alloy melt 11 fills the spaces of short fiber layer 3 of the preform under pressure, and the preform and core 10 are surrounded by Al alloy melt 11.

In this case, standard components and conditions are used for the Al alloy component, temperature of the melt, and pressure of the melt. As an example, the components and conditions shown below can be used.

Al alloy component:

(wt%)

Cu	Si	Mg	Zn	Fe	Mn	Ni	Al
1.0	11.0	0.8	0.05	0.1	0.05	1.2	balance

Temperature of melt: 750°C

Melt pressure: 600 kg/cm^2

In the above-mentioned pressure molding, preform 1 is influenced by the pressure of the melt. However, the preform is reinforced with porous core material 2, and the rigidity of the aforementioned preform is increased; thus, formation of cracks in the preform as a result of the pressure of the melt can be prevented.

Furthermore, in general, the preform is shifted from the mounting position in die 8 due to the pressure of melt, but as described above, the preform can be securely retained in die 8 as a result of the porous core material that serves as a reinforcement material, and shifting of the preform from the mounting position in die 8 due to the pressure of melt can be prevented.

Furthermore, the preform prevents short fiber layer 3 from coming in direct contact with die 8 and the porous core material 2 supports the preform away from the die at both ends, and as described above, the both ends 2a of the porous core material 2 extend beyond the end faces 3a of the short fiber layer; thus, both ends 2a come in direct contact with melt 11. Therefore, pressure of the preform by the melt can be achieved from porous core material 2 (inside) as well, and the integrity of the composite formation can be assured.

v) Finally, a heat-treatment is provided.

For the heat-treatment, solution heat-treatment and aging are carried out to form an intermetallic compound and to increase the strength. Standard conditions, for example, a

solution heat-treatment at 520°C x 4 hours, followed by water chilling and aging at 170°C x 10 hrs, are carried out, in this case in air.

[p. 4]

After the above-mentioned heat-treatment, mechanical processing of the molded article with apex seal grooves 14 as shown in Fig. 5 and Fig. 6 is carried out and production of rotor 13 is achieved.

In this manner, porous Ni composite member 15 and alumina short fiber composite member 16 are formed around the apex seal groove 14 as shown in Fig. 6. In the above-mentioned porous Ni composite member 15, a Ni-Al intermetallic compound layer is formed as a result of the aforementioned heat-treatment, and the wear resistance is increased, and in alumina short fiber composite member 16, hardness and settling resistance can be increased based on the alumina short fiber.

Therefore, settling resistance is required at the ends 14a around the periphery of the apex seal groove 14, and wear resistance is required at the bottom 14b of the aforementioned groove 14, but as described above, the above-mentioned requirements can be adequately met upon formation of the aforementioned porous Ni composite member and alumina short fiber composite member.

Fig. 7 through Fig. 9 show other application examples. In the above-mentioned application examples, the same call-out codes refer to the same components as above.

In this case, formation of a composite is surely achieved and the thermal conductivity at and around the apex seal groove is increased.

In other words, first, apex seal groove 14 reinforcement short fiber molded article 17 is prepared. As shown in Fig. 7, vertical slot 18 and many horizontal slots 19 are formed in the above-mentioned short fiber molded article 17, and in this case, the arrangement is such that vertical slot 18 locates the bottom member 14b of the apex seal groove 14 at the time of completion of rotor 13. In this case, the short fiber shown below is used for short fiber molded article 17a.

Composition	Al_2O_3 95 wt%, SiO_2 5wt%
Specific gravity	3.3
Mean fiber diameter	3 μm
Mean fiber length	Several hundred μm
Coefficient of linear expansion	7.8×10^{-6} /°C
Tensile strength	200 kg/mm^2
Young's modulus	30000 kg/mm^2

As shown in the application example above, the above-mentioned short fiber-molded article is produced by pressure molding, and the area corresponding to the porous core material is formed into a composite and forms composite member 20 as shown in Fig. 8, and short fibers are absent in the vertical slot 18 and horizontal slot 19; thus, non-composite member 21 is formed. Subsequently, as shown in Fig. 9, machine fabrication is carried out to produce apex seal groove 14 and non-composite member 21 corresponding to the aforementioned vertical slot 18 located at bottom member 14b of the aforementioned groove 14.

Therefore, in the above-mentioned structure, the melt flows into vertical slot 18 and horizontal slot 19, and permeates into the short fiber molded article 17 as well, and the composite formation is reinforced. Furthermore, both slots 18 are non-composite areas; thus, thermal

conductivity is increased and release of heat at the apex seal groove 14 is likely to be achieved upon driving of rotor 13, and an increase in temperature at groove 14 can be effectively prevented.

[Effect of the invention]

As described above, robbing of the heat in the preform by the die can be controlled as much as possible.

Furthermore, crack formation in the preform caused by the pressure of melt can be prevented.

Furthermore, retention of the preform in the mounted position can be securely achieved.

And furthermore, the melt can permeate from the porous core material side as well, and formation of composite can be surely achieved.

[p. 5]

4. Brief description of figures

Fig. 1 is a perspective view of the preform.

Fig. 2 is a vertical cross-section view of Fig. 1.

Fig. 3 is an explanatory drawing used for illustration of the molding process of the preform.

Fig. 4 is the explanatory drawing used for illustration of the melt molding method.

Fig. 5 is a perspective view that shows the rotor of the rotary engine.

Fig. 6 is an enlarged cross-section view at line V-V of Fig. 5.

Fig. 7 is a perspective view that shows the short fiber-molded article of a different application example.

Fig. 8 is a vertical cross-section view that shows the condition after molding of the short fiber-molded article.

Fig. 9 is a partially enlarged perspective view that shows the apex seal groove of a completed rotor.

Explanation of codes

1: Preform

2: Porous core material

3: Short fiber layer

8: Die

Applicant: Mazda Corp.

Agent: Minoru Murata, Patent attorney

Fig. 1

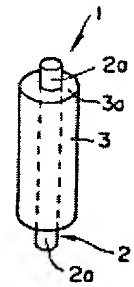

Fig. 2

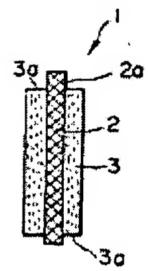

Fig. 3

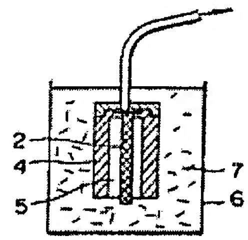

Fig. 4

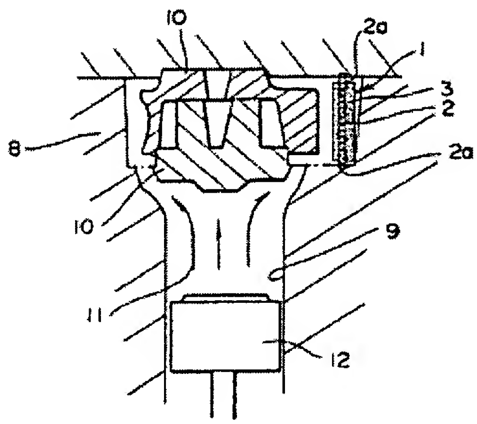

Fig. 5

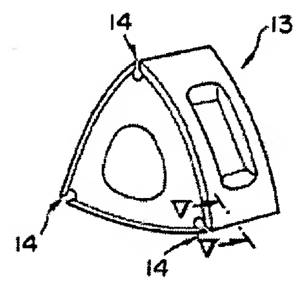

Fig. 6

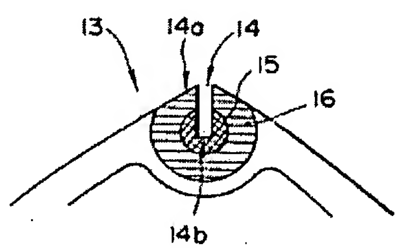

Fig. 7

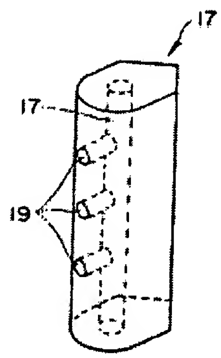

Fig. 8

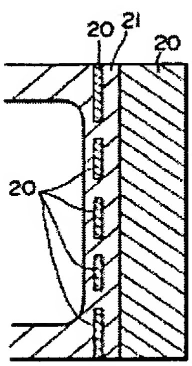

Fig. 9